Abstract - Production planning is considered as crucial for the success of operation in production management and represents an important role in the performance of the supply chain. Production planning as a critical phase of supply chain management in general and in manufacturing system in particular is a multi-parameters decision-making issue. Generally, the process of production planning the most suitable and appropriate planning has multiple complexities and obstacles that holds multiple-parameters. This paper handles the production planning problem in a Moroccan Marble company. The present study presents an integrated distributed manufacturing planning approach based on multi-agent system methods in order to solve the issues related to the production planning procedure within Marble company with the help of the Agile Production Planning model and Collaborative Production Planning model within the context of DPP. The study starts with reviewing the previous works of multi-parameters manufacturing planning systems method. Then, the set of parameters is selected based on the company requirements and the team’s interview. In the case study, the feasibility and the reliability of the model was verified by the experts within the company. The final results affirm that the integrated holistic approach could be efficient in terms of money, time and effort and in comparison to the existing models so as to overcome to complexities and uncertainties production planning issues and obstacles in the production system.

Key words : MAS, production planning, Distributed manufacturing system, Agility, Collaboration

I. Introduction

The fast changes of customers’ needs and demand are the main worldwide changes that are pushing production systems through and intense and fast development [35]. Seeking competitiveness in this sense put production systems under the obligation of reducing the product lifecycles, inventories’ levels, intense resources exploitation and short lead times. Based on the literature in regards to the manufacturing development, different authors have different focus areas [26]. Currently, multiple companies started to grasp the idea that the production system and the production planning has an impact on the performance hence they have started to take advantage of technological development [8]. Therefore, exploitation of technology in developing countries may have evoked some certain phenomenon and the procedure of production systems and production planning has become more complex and the supply chain partners turned into fragments, each trying to solve and correctly exploit the development systems. This for instance, certainly reflects negatively on the products and the service quality and the organization’s performance [43]. As a matter of fact, the capability of a company to exploit and apply intelligent and developed technologies has become extremely important for the supply performance [47]. By way of explanation, production planning is considered as one of the most valuable problems for building a cornerstone in production. The core objective of the production planning procedure is to reduce all kind of uncertainties and ambiguities and increase the value of collaboration and coordination between partners [8]. Recently, the main objective of production planning is to pick up the most appropriate and suitable panning and schedule with the highest capabilities in delivering high-quality products/services at an affordable cost at the minimum time based on extreme intelligent [14]. Generally, previous works have developed various models for production systems and specifically for production planning with regard to decision-making methods [35].

Nevertheless, these adopted methods such as multi-agent systems mechanisms are not sufficient and able to solve the complexity of nowadays production systems [43]. Hence, the current supply chain has become way complex and ramified where disturbance can come at any time [45]. Previous researchers have developed numerous studies in this domain that generally involve the adoption of the practical approaches and the application of a broader set of methodologies. Consequently, various multi-agent system methods have been formulated in order to re-arrange and support difficult decisions such as production planning [46]. The procedure for production planning the most appropriate and suitable planning in terms of multi-parameters depending on the production systems and its requirements encompasses a broader range of external and internal influencing indicators [28]. Currently, planning the most appropriate production system not only relies on investigating cost and supplier but also relies on a broader set of parameters such as quality, process, technological capability, decision-taking. The designation of the production system and the planning system of each defined parameter changes from field to field. For instance, organizations from different areas ought to embrace a strategic approach based on a smart technological system in order to facilitate the production system and the interaction between the partners and prevents the application of system to all cases and operations [40].

Adopting a smart self-adaptive system approach that relies on technology can reduce the risk of production or service disruptions. The key challenge in this scenario is not only to identify the main appropriate system, but rather develop new approaches and methodologies to highlight production planning problems and solve the significant complexity within the supply chain. The ambiguity
and the uncertainty are the main issues of production planning specifically when the assessment procedure is handled by human judgment [41]. Based on theory, as presented in section 2, the prior studies have mostly focused on the Fuzzy set theory, simulation theory or Hybrid theory and few limited works have taken MAS theory into consideration in solving production planning. The main contribution of the present study is to present a Holistic (DACPP) integrated approach, which consists of DCPP to assure the collaboration and coordination withing production planning system and DAPP to track the planning and scheduling, to handle uncertainty in the Production planning and eliminate delays. Later on, a case study of Moroccan Marble manufacturing Company will be investigated to verify the constructed model and to show the feasibility of the suggested techniques. The present paper is structured as follows: Section 2 reveals the prior works on PPS methods and MAS models used for lapping the problems faced throughout the process of appropriate production planning. Section 3 highlights the development of DACPP-MAS based model with the use of DCPP and DAPP mechanisms. Section 4 studies the application and the verification of the constructed model in a case study of Moroccan Marble manufacturing Company. Section 5 presents the final results and discussions for future researches. Section 6 concludes the present work and proposes some valuable recommendations for future researches.

II. Literature review

In this section, the literature review is mainly divided into two sections. First, the production planning systems will be reviewed [by previous works]. Then, the suitable systems in planning and scheduling manufacturing for the present work will be sketched. Second, some of the Multi-agent system methods studied in previous works for defeat the problem of production planning will be also pointed out.

1. Production planning systems

In order to achieve a successful production planning in manufacturing companies researches need to take under considerations multiple parameters depending on the system of production. Commonly, the selection of appropriate system represents a basic step in the manufacturing procedure for production planning based on multiple parameters [28], [49] the conventional planning systems generally concentrate on the customer service level (delivery) to carry out the production planning and control for the objectives. [46] declared that capacity, amount of production tasks or accidents and performance index [inventory level, production equilibrium, overtime production...] are criteria that need to be considered in terms of production system selection. These factors are interrelated and restricted with each other, which have great impacts on the enterprise’s production planning. [37] emphasizes on the their paper the importance of the data quality and the real-time processing of these data in production planning. [24] conducted a study that encompasses eight essential parameters which paid, later on, attention by numerous researchers from different fields of study. This set of criteria is as follows: Product, technology life cycles, demand for products, delivery times, pricing, production costs and product quality standards. However, this range of criteria can vary from one study to another. In the present work, the range of criteria will be selected and designated based on the production system requirements within the marble industry. The present study production system is distributed Agile-collaborative production planning system (DACPP) encompasses data quality, cost, technological capability, technical support, delivery, agility, intelligence...

<table>
<thead>
<tr>
<th>Authors</th>
<th>Production planning system</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang &amp; Lin 2010</td>
<td>Agile manufacturing planning</td>
<td>the performance of customer service level short ordering-to-delivery time,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>low price, effectiveness, flexibility, visibility, accountability, track</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ability and traceability and information.</td>
</tr>
<tr>
<td>Chen, 2010</td>
<td>Distributed Collaborative Production Planning</td>
<td>Resources, decisions, operation and flexibility and intelligence.</td>
</tr>
<tr>
<td>Hees &amp; Reinhart,</td>
<td>Integrated production-planning considering manufacturing</td>
<td>Demand, flexibility, capacity, partner, volume, materials, quality,</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td>technology and product.</td>
</tr>
<tr>
<td>Wang &amp; Liu 2013</td>
<td>Integrated production planning and control</td>
<td>Demand, materials, capacity, delivery, production balance, inventory,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>production timing</td>
</tr>
<tr>
<td>Giordani et al.,</td>
<td>A distributed multi-agent production planning and</td>
<td>Intelligence, technological capability, agility, efficiency</td>
</tr>
<tr>
<td>2013</td>
<td>scheduling framework for mobile robots</td>
<td></td>
</tr>
<tr>
<td>Margaretha et al.,</td>
<td>Hierarchical planning in a make-to-order production</td>
<td>Planned leadtime, safety stocks and lotsizes.</td>
</tr>
<tr>
<td>2013</td>
<td>environment</td>
<td></td>
</tr>
<tr>
<td>O’Reilly, 2015</td>
<td>The hierarchical production planning</td>
<td>Volume, variety and forecast.</td>
</tr>
<tr>
<td>Andreas &amp;</td>
<td>Reconfigurable Manufacturing Systems</td>
<td>Flexibility, process, cost and quality.</td>
</tr>
<tr>
<td>Gunther, 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margaretha, 2015</td>
<td>Aggregate planning and forecasting in make-to-order</td>
<td>Capacity, quantity and performance.</td>
</tr>
<tr>
<td></td>
<td>production systems</td>
<td></td>
</tr>
<tr>
<td>Gholamian, 2016</td>
<td>Multi-objective multi-product multi-site aggregate</td>
<td>Efficiency, relationships and demand.</td>
</tr>
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<td></td>
<td>production planning</td>
<td></td>
</tr>
<tr>
<td>Gyulai et al., 2017</td>
<td>Robust production planning and control for multistage</td>
<td>Volumes, flexibility, demand, capacity, time, process and machinery.</td>
</tr>
<tr>
<td></td>
<td>systems with flexible final assembly lines</td>
<td></td>
</tr>
</tbody>
</table>
Fang et al., 2017  Hybrid production systems  Capacity, cost and demand.

Altaf et al., 2018  Integrated production planning and control system  Technology, data and facility.

Wang et al., 2019  Production planning for additive manufacturing  Demand, efficiency, schedule, time and intelligence.

Cheraghalikhani et al., 2019  Aggregate production planning  Workforce, time, capacity and demand.

The present paper  Distributed Agile-collaborative production planning  Data quality, technological capability, technical support, delivery, agility, process, decision-taking and intelligence.

2. Review of prior works based on multi-parameters handling the diversity of production planning systems with different approaches and methods

Since manufacturing systems are evolving, the production environment needs to cope up with the fast changing in relation to the market environment and customer requirements. In manufacturing systems literature, many authors present their work on reviewing manufacturing system and the planning approaches and methods. The modern manufacturing industry has to adopt different techniques of manufacturing to address the needs of consumer driven global market. The literature is full of extensive research on integration methodologies like multi-agent simulation, game theory, Nash equilibrium, genetic algorithm ([23]; [25]). As for instance, [27], emphasized in an early study that production means need to become reconfigurable and founded on autonomous, agile and intelligent paradigms, which dynamically interact with each other for the achievement of local and global objectives. This statement was more developed in the work of [6] since they have highlighted the importance of integration, common management systems and collaboration with other companies in order to stand for a global competitiveness and rapid market response. They stated that collaborative strategies and partnerships are the key of a win-win strategy. With these mistakes, researches started to study the production planning system applying, mathematical, algorithmic methods and approaches integrating a common and shared management systems. In this sense, [35] studies the mathematical programming models for supply chain production planning. Based on the previous method, [46] studied the application of an optimization model for an integrated production planning. While [16] added the simulation concept to the optimization methods for production planning. The recent study of [2] added the application of RFID to the simulation concept. A previous work of [41] studied finite-capacity MRP in production planning. Last but not least, an important number of studies discussed the multi-agent based system for manufacturing planning.

Chart 2 Summary of production planning methods in prior researches

Authors  Method
Chen, 2010  DCPP- Multi-Agent System Framework and Coordination Technology
Kumar & Mishra, 2011  Multi-Agent Self Correcting Architecture
Hees & Reinhart, 2015  Fuzzy AHP–GP approach
Mahdavi, 2011  Fuzzy goal programming-based approach for solving a multi-objective mathematical model of cell formation
Jianmai, 2011  Lagrangian relaxation-based approach
Mirzapour, 2011  Multi-objective robust optimization model
Leitao et al., 2012  Bio-inspired multi-agent systems
[46]  Multi-objective optimization model
Gansterer, 2013  Simulation-based optimization
Albey et al., 2015  Demand Modeling With Forecast Evolution
Chien et al., 2015  Agent-based negotiation mechanism
Zhang et al., 2016  A novel Lagrangian relax-and-fix heuristic approach
Gould et al., 2016  A material flow modelling tool
Rossi et al., 2016  Finite-capacity MRP based on linear programming
He et al., 2016  Agent-based hierarchical production planning and scheduling
Osorio et al., 2016  Simulation-optimization model
Dallasega et al., 2017  Simulation based production planning supported by ICT Real-Time-Capability
Block et al., 2017  Human Centered Multi-Agent-System
Altaf et al., 2018  Simulation-based optimization using RFID technology and data mining
Wang et al., 2019  A computer vision-based approach
Podvalny et al., 2019  Digital production and multi-agent systems approach

3. Review of prior works about MAS methods for manufacturing planning

A Multi-agent-based production planning has been established in multiple studies and previous work for solving the production planning problems, with advantages of flexible system architectures and responsive fault tolerance. In consideration of the scheduling requirements and availability of manufacturing resources, the actual process plan and schedule for producing a particular product are determined through negotiation between part agents and machine agents representing parts and machines respectively [31]. Based in this concept, multiple methods were either on this basis of MAS or integrated with MAS model with the purpose of overcoming the complexity discovered through the process of production planning however, the majority of researchers have mostly focused on Demand-Delivery-Cost methods, with complex mathematical models, to resolve the production planning problems. In literature, however, various studies have tackled and proposed different techniques in a variety of ways for overcoming the issue of complexity in production planning based on multi-agent systems. Table 3 highlights and summarizes the most important methods adopted by several researchers for production planning based on multi-agent systems.

Chart 3 Review of prior researches in applying MAS models for manufacturing planning
<table>
<thead>
<tr>
<th>Authors</th>
<th>Methods</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kang &amp; Choi, 2010</td>
<td>MA-based search for intelligent PPS</td>
<td>They developed an MSMLDM-KDOS- MABBS model to provide a practical solution for complex real-world production planning and scheduling problems.</td>
</tr>
<tr>
<td>Wang and Lin, 2010</td>
<td>RFID-MAS for AMPCS</td>
<td>They demonstrated that MAS-RFID model an agile AMPCS can possess the characteristics of visibility, accountability, track ability, responsiveness, and flexibility in a distributed and dynamic manufacturing environment.</td>
</tr>
<tr>
<td>Kumar &amp; Mishra, 2011</td>
<td>A MA-Self Correcting Architecture for Distributed Manufacturing</td>
<td>They proposed an agent architecture that will assist in effective communication among the different components of the SC for DMS and will automatically make required effective decisions.</td>
</tr>
<tr>
<td>Leitao et al., 2011</td>
<td>Bio-inspired MAS for reconfigurable manufacturing systems</td>
<td>They proved that MS must exhibit flexibility, robustness, re-configurability and responsiveness, based on decentralization of the control over distributed, simple and autonomous entities, which cooperate to achieve the system’s objectives.</td>
</tr>
<tr>
<td>Renna, 2011</td>
<td>MA-based scheduling in manufacturing cells in a dynamic environment</td>
<td>They conducted a simulations in a dynamic environment with several conditions and with internal and external changes. They proved that the dynamicity depends on external characteristics hence, he proposed approach reduces its advantages.</td>
</tr>
<tr>
<td>Guo et al., 2013</td>
<td>C-IDMC for order tracking and allocation in apparel manufacturing</td>
<td>They proposed a Cloud-based IDM system which contains multiple models. Which will allow a company to obtain high performance in SC coordination and production decisions.</td>
</tr>
<tr>
<td>Chien et al., 2013</td>
<td>Agent-based negotiation mechanism for multi-project HRA</td>
<td>They developed a decision model bases on MAS that integrated various functional criteria and design hierarchy of collaborators in the distributed environment to improve decision-making quality. MAS simulates the non-transparent information</td>
</tr>
<tr>
<td>Lim et al., 2013</td>
<td>A MAS to optimise resource utilisation in multi-site manufacturing facilities</td>
<td>They proposed a MAS to optimise the resources within a multi-site manufacturing environment, in particular through the integration of process planning and production scheduling functions.</td>
</tr>
<tr>
<td>Giordani et al., 2013</td>
<td>A distributed multi-agent production planning and scheduling framework for mobile robots</td>
<td>They proposed a solution in terms of a two-level decentralized multi-agent system (MAS) framework in order to minimize production costs based on a dynamic determination of the number of robots on each production task and the individual robot allocation.</td>
</tr>
<tr>
<td>Barbosa et al., 2014</td>
<td>ADACOR in MA manufacturing systems</td>
<td>They proposed an innovative control architecture called ADACOR, which considers the introduction of a two-vector self-organization mechanism: behavioural self-organization, found at microlevel, which allows the system to respond smoothly to perturbations, and structural self-organization, displayed at macro-level, which lets the system react more drastically.</td>
</tr>
<tr>
<td>Block et al., 2016</td>
<td>A Human Centered MAS for PPC</td>
<td>They developed solution is agent-based to integrate the role of the production planner in the autonomous PPC.</td>
</tr>
<tr>
<td>He et al., 2016</td>
<td>Agent-based HPPS in MTO manufacturing system</td>
<td>They demonstrated the hierarchical agent bidding mechanism for assisting MTO manufacturing systems in global optimised and flexible PPS. This mechanism is able to consider structural constraints of MS in PP and scheduling process.</td>
</tr>
<tr>
<td>Mishra et al., 2016</td>
<td>C-MA architecture for effective PS of distributed manufacturing</td>
<td>They proposed a cloud-based MA-framework for distributed manufacturing. This framework is flexible enough to be used on most of the manufacturing systems.</td>
</tr>
<tr>
<td>Wojtak et al., 2017</td>
<td>MAS to support PP</td>
<td>They proposed an approach based on MAS to solve the ambiguity that SMEs have regarding their production process.</td>
</tr>
<tr>
<td>Podvalny et al., 2019</td>
<td>A MAS-architecture approach to organize PP</td>
<td>They developed a MAS based approach that allows organizing a workflow between the programmed agents in the IoT concept. The proposed approach based on a service-oriented architecture,</td>
</tr>
</tbody>
</table>

**Abstract**

They proposed an innovative control architecture called ADACOR, which considers the introduction of a two-vector self-organization mechanism: behavioural self-organization, found at micro-level, which allows the system to respond smoothly to perturbations, and structural self-organization, displayed at macro-level, which lets the system react more drastically. They developed a solution is agent-based to integrate the role of the production planner in the autonomous PPC. They demonstrated the hierarchical agent bidding mechanism for assisting MTO manufacturing systems in global optimised and flexible PPS. This mechanism is able to consider structural constraints of MS in PP and scheduling process. They proposed a cloud-based MA-framework for distributed manufacturing. This framework is flexible enough to be used on most of the manufacturing systems. They proposed an approach based on MAS to solve the ambiguity that SMEs have regarding their production process. They developed a MAS based approach that allows organizing a workflow between the programmed agents in the IoT concept. The proposed approach based on a service-oriented architecture,
In theory, few researchers discussed the Distributed Agile-Collaborative manufacturing system theory to support manufacturing planning in production systems. Therefore, it is noticed that during the last decades the Distributed Agile-Collaborative manufacturing system has been recognized by numerous researchers as a successful approach generally in economy and more specifically in industrial field ([5] [39]).

The core objective of the present study is to adopt a Distributed Agile-Collaborative manufacturing system theory based on MAS models to support manufacturing planning and overcome the complexity highlighted during the process of production by selecting the most appropriate and suitable planning. Consequently, the main role of the developed DACPP model here is to handle the ambiguity exposed in the manufacturing planning procedure. The distributed Agile-Collaborative manufacturing systems theory used within this study pulls variable advantages (e.g. [1] [9] [12] [34] [49] [10] [30]):

- The Distributed Agile-collaborative manufacturing systems theory provides concentrated results employing huge amount of data (Big Data) compared with other separated modelling methods and techniques.
- It is considered as one of the innovative theories in terms of the amount, consistency and quality of information.
- Based on the theory, it is proved that a distributed Agile-collaborative manufacturing-based method improves the performance of a manufacturing enterprise in terms of the reliability, responsiveness, flexibility, cost.
- It is better than other set of theory in term of the conditions, risks and uncertainties
- The advantages of this method over other set of theories are that it is developed under simple, small, clear, well defined and concentrated tasks
- It can handle the amount of risk and uncertainty related to manufacturing systems and in particular in production planning problems.
- It boosts collaboration and coordination among trading partners for intelligent decision-making
- It assures the possibility of work simultaneously with different planning concepts including multiple parameters
- It is flexible, highly configurable, and easily adaptable to the dynamic changing environment.
- It can quickly and dynamically respond to the external and internal environment changes.

III. DACPP model: an integrated approach of DCPP and DAPP

The multi-agent system (MAS) methods, models, frameworks or paradigms support the presence of several decision making entities, distributed inside the manufacturing system, interacting and cooperating with each other as to reach the optimal global performance. These systems has represented a real breakthrough in the world of research, involving researchers and practitioners coming from heterogeneous and, often, distant fields. It has in fact attracted, among others, biologists, game theorists, AI researchers, social scientists and management scientists 12. In this paper, a DACPP integrated model of DCPP and DAPP is developed to determine the most appropriate and suitable manufacturing planning for a Moroccan Marble company.

DCPP model which is designed to support the collaboration among partners. In one hand, the operation of sub-systems of a manufactur is often optimized locally in a distributed manner, but an overall optimization of the manufactur is missing on the operational level. On the other hand, it is unrealistic to build large centralized optimization models that take account of every factor that impacts the production process due to the large computational effort and the problem to keep the models up to date. Therefore the coordination methods for the existing distributed systems interfere ([3] [9]). MAS in this paper is used as technology base for supporting the previous mentioned problem regarding collaboration and coordination among partners in production planning.

1.1 Coordination in DPP system

Generally speaking, coordination can be viewed as various decisions to ensure that common objectives are achieved (coherence of actions), while preventing chaos (conflict of actions). There are specific sub-types communications that are related to coordination (Biggers & Ioerger, 2001):

- Synchronization
- Disambiguating a sharing responsibility (role selection)
- Altering of failure
- Assistance offers or requests between team members
- Information requests and distribution
- Ambiguous information resolution

In the distributed networked manufacturing system, there are three levels of coordination units: inter-firm coordination units, inter-department of firm coordination units, and inter-machine of job shop coordination units. The most critical functionalities required for coordination unit are planning and coordination, including [8]:

- Order acceptance coordination between manufacturer and customer.
- Order configuration and splitting coordination among collaborative partners.
- Operational planning coordination between production and other function department.
- Capacity planning coordination among production units.
- Materials coordination between manufacturer and suppliers.

To realize these functions, multi-agent system coordination can be implemented using different methods. In this system design, a communication base system was chosen as a coordination mechanism. It presents knowledge source, scheduling interface and task allocation.

1.2 DCPP based on MAS architecture

Using multi-agent architecture, this system comprises different module layers:

1st layer (resource management): includes materials resource, human resource, technique resource and equipment resource.
2nd layer (business operation): contains different business modules in a manufacturing company, such as purchasing and supplying, production operations, inventory and distribution.
3rd layer (planning decision-making): presents the core function of the system which includes collaborative demand management, collaborative master production planning and scheduling, collaborative materials planning and partner selection module.
4th layer (communication): is responsible for the information communication among partners using Internet, XPS and SCADA.
Planning view highly Improves the performance of PP. In this sense planning which can quickly and dynamically respond to the external effect effectively utilize these real-time valuable information this open deliver process, and return process of a manufacturing enterprise can this system are:

- Multi-agent structure technology application. All function modules of the system are consisted of multi-agent structure, this makes the system has properties of autonomy, reactivity and pro-activity.
- Coordination based plan decision-making method. Unlike the traditional plan decision is made by one company, this system increases the coordination function between partners in networked manufacturing system.
- Internet based communication technology. The system is developed using J2EE/ Web Service platform, the communication is through internet and World Wide Web, it is typical business – Business (B2B) approach which makes the online communication and inter-firm negotiation possible.
- Demand cooperation driven production plan making mode. First, four types of customers in term of two dimensions of characteristics -- information sharing degree and customer involving degree are identified; then four types production plan decision making modes are distinguished.

2. **DAPP model based on MAS to support the agility of production system**

According to [48] the plan process, source process, make process, deliver process, and return process of a manufacturing enterprise can effectively utilize these real-time valuable information this open planning view highly Improves the performance of PP. In this sense an agile manufacturing system characterized by being flexible, highly configurable, and easily adaptable to the dynamic changing environment must be developed. Which makes it necessary to develop an intelligent, autonomous, and distributed manufacturing planning which can quickly and dynamically respond to the external and internal environment changes.

2.1 **Agility in DPP system**

Based on this system, the agent-based agile manufacturing planning system has the capability of monitoring all the production process activities, performing a real-time what-if simulation, planning and analysis, actively alerting each object’s production activities. Therefore, the main characteristics/functions of this model may be summarized as follows:

- Timely generate accountable production and operations schedule: DAPP increases the visibility of shop floor information and ensures the accountability of production and operations schedule based on the timely and active production information collected from items and equipment configured on SCADA and connected to the captors and sensors.
- DAPP effectively track and guide shop floor operations through the SCADA mechanism according to the planned operations schedule and controls the progress of shop floor operations to meet the planned schedule by classifying the causes of abnormality and alert related modules to identify the feasible alternatives once an abnormal event is detected. In addition, it also has the capability of effectively tracing the timely detailed production information for each demand order through SCADA mechanism.
- Real-time evaluate production performance: DAPP may evaluate both the effectiveness of the generated production and operations schedule and the performance of shop floor execution.

2.2 **DAPP based in MAS architecture**

The framework of a DAPP which is composed of three major modules: the advanced manufacturing planning (AMP), the SCADA-based manufacturing control (SCADA-MC), and the performance analysis (PA). The proposed DAPP can also integrate with external information application systems to respond to the external changing environment. The role and functions of AMP, S-MC and PA are briefly described as follows:

1\textsuperscript{st} module (DPP): The agent-based DPP module is responsible for generating accountable production and operations schedule based on the demand information inputs from master production schedule (MPS) and the timely and active production information and events provided by the SCADA-based manufacturing control (SCADA-MC) module and performance analysis (PA) module, respectively.
2\textsuperscript{nd} module (SCADA-MC): SCADA-MC module plays the role of effectively tracking and controlling the execution of a manufacturing system in which production items and manufacturing resources attached with SCADA mechanism may actively feedback production status to and receive production operations schedule from distributed production planning (DPP) module.
3\textsuperscript{rd} module (PA): PA module is an event-driven monitoring mechanism which evaluates the inbound, production, and outbound logistics performance of a manufacturing system. Specifically speaking, PA module is responsible for monitoring and evaluating the normal and abnormal events of each manufacturing order’s shop floor operation tasks. Whenever an abnormal event is detected, PA module will classify the causes of abnormality and alert related modules to identify the feasible alternatives and evaluate the effectiveness of the new alternative. Besides, PA module will also employ a simulation sub-module to evaluate the effectiveness of production and operations planning, schedule and the performance of shop floor execution, based on the real-time manufacturing information provided by SCADA mechanism.
For instance, scheduling agent (SA) in (AMP) module will generate the production schedule based on demand priority and production information from order sequencing agent (OSA) and job management agent (JMA), respectively. Furthermore, (SA) will also generate the operations schedule. To overcome the structural rigidity in manufacturing planning system (MPS), the decision for assigning an appropriate manufacturing resource to each operation task is obtained from the bidding process between process control agent (PCA) and resource agent (RA). At the shop floor execution level, an item mobile agent (IMA), embedded with a SCADA mechanism, will process the operation task based on the production instruction from (PCA). (IMA) will send the production information to (PCA) through SCADA-middleware agent (SCADA-MWA) and data agent (DA) to check whether it needs to continue its next operations or to finish the corresponding manufacturing order (MO) whenever an (IMA) completes an operation task. Then, (PCA) will send the production information operation task’s actual start/end time to (JMA) to check whether this manufacturing order is completed or not. When an (IMA) replies ‘abnormal’ message to (PCA), (SA) may consequently receive that ‘abnormal’ message. Through the bidding process, (PCA) may select another appropriate manufacturing resource and (SA) may need to re-generate a new operations schedule and send this new operations schedule to (IMA) to continue its operation task. An event monitoring agent (EMA) may monitor each (MO), lot, and item’s manufacturing activities based on the event information obtained from (JMA), (PCA), and (IMA), respectively. Whenever (EMA) receives an ‘abnormal’ message, it will classify the abnormal cause and notice event alert agent (EAA) to send ‘warning’ message to related agents. Besides, simulation sub-module will evaluate both the expected performance of production and operations schedule and the performance of production execution.

The main method of this research is based on working on a single agent behaviour in order to reach the final result and verify the abovementioned model. At the basis of these models is that, from the local autonomous and often conflicting behaviours of the single decision-making units, a global behaviour of the manufacturing system emerges, coherent with the requested characteristics of reactivity and flexibility ([8] [7]).

IV. Case study: Moroccan Marble Manufacturing

In the present paper, the development of the DACPP-MAS based integrated model is applied and verified within a Moroccan Marble manufacturing company. A very qualified team, involving the manufacturing operation manager, operation planning manager, operation execution manager, operating system administrator, operating system supervisor and the process engineer, were consulted. As mentioned above, the present study focuses on eight main parameters with regard to the marble manufacturing company production planning strategy requirements, gaps and needs. However, this set of parameters is presented as follows:

- Data quality,
- Technological capability,
- Coordination,
- Human,
- Agility,
- Process,
- Decision-taking
- Intelligence.

Generally, the structure of agent is different in systems, but there are some common components or functions modules are used in many systems. Moreover, the integration of supporting technologies has a huge contribution in the structure of a MAS Figure 3 is function structure of single agent.
The proposed model is constructed with the support and the assessments, supervision and the assistance of this qualified team.

(1) Communication unit: is responsible for the communication with another agent. Widely accepted communication language for agent is ACL. KMQ is one communication language based on information. In the communication unit, there is machine or human user interface, communication protocol and coordination module.

(2) Data base and knowledge base: is the base for solving problem, when agent solves problems, it need access the data base or knowledge base to utilize the historical data and knowledge.

(3) Problem solver: is the core of an agent, it is responsible for the problem analysis and solving through learning and reasoning function, it must have some algorithms for solving problems.

(4) Function components: includes the task decomposition, task allocation, and evaluation of plan. This is a supporting decisions unit for the problem solving in reasoning and learning modules.

(5) Information handler: includes scenario handling module, data quality module, decision-taking module and interaction module. Based on SCADA and smart agents the additional function and modules will give the opportunity to production planning to be self-adaptive and agent can take new decisions by themselves based on previous scenarios and events. Hence, they will act based on the output.

After using DACPP-MAS based model, is applied in coherence with the structure frame work of the marble manufacturing in reference with the parameters. The added modules to the single agent give the DACPP model the feasibility to evolve towards self-re-engineering.

Mainly the idea here is that both models have common function and common module. The integration feasibility of both models was verified and reliability was also verified since the non-common modules were considered as complimentary to each module, thus the results is a holistic model for distributed manufacturing system based on technological capability and technical suppport. Furthermore, the adjusted model that included extra modules to solve the problem and the gaps discussed in the literature were verified and extremely proved that theory of a the impact of single agent.

V. Results and discussion

From the model reliability perspective, the DACPP model results expose that the focused adjustment on one single agent based on the parameters of production planning has a valuable reflection in the agent-based model. However, the model results also show that integration of both model (DCPP and DAPP) gives the production planning a holistic approach and solve far issues related to uncertainties and ambiguities that we’ve already discussed above. The use of DACPP-MAS-based model in the present work provides clear vision considering multi-parameters of production systems in order to achieve a successful, disturbance free production planning it also generates alternatives, solutions and actions with regard to the company requirements and production system strategy. This aspect is the main contribution of this model in terms of previous researches as shown in the chart below.

Chart 4 Comparison matrix regarding DACPP-MAS based under multi-parameters in decision-making

The DPP integrated model is able to offer precise information in very less complexity. By way of explanation, production planning is achieved in a concise period with defined numbers of tasks, sequences and operations. In terms of academical direction, the present work presents a DPP integrated model consisting of CPP and APP for production planning in a complex, uncertain and technology supported environment. The main challenge addressed within this work is to assess all the uncertainties, parameters and complexities found during the process of production planning due to the fuzziness of the collected data in very short period. In addition, the model was based on a qualitative approach, thus it was not mathematically studied for the complexity and the huge number of variables and parameters included in the Models. Nevertheless, the final results affirm that this approach could be applied in real world and could be mathematically studied. Moreover, the DPP integrated multi-parameters MAS-based approach could be further studies and investigated for validation and also further studies could be done regarding a developed model that do not rely on the output to take decision in terms of new event and action and can simply re-act or pre-act based on its self-learning capabilities and smartness even if the variables are totally new and were never tackled neither the data based on knowledge base. Furthermore, the communication platform needs some further investigations in terms of receiving and reading all kind of files and handle computer and system-based errors need to be tackled within production planning in order to reduce the delays in operation and execution phase.
VI. Conclusion

With the trend of supply chain globalization, today’s supply chain network is becoming geographically spread out across the globe. In this sense, it is world widely observed that continuous changes pushed manufacturing and production towards intense development and that’s because of the fast changes of customers’ needs and demand. In today’s manufacturing enterprise, the performance of customer service level is highly dependent on the effectiveness of its manufacturing planning. The performance of a supply chain this context may not be improved unless all the process related to the manufacturing company can effectively utilize real-time valuable information. In other words, not only an agile manufacturing system which is flexible, highly configurable, and easily adaptable to the dynamic changing environment must be developed but also a collaborative manufacturing system must be developed to ensure the fluidity, availability and the accessibility to all information at any time and every time. To cope with these requirements, it is necessary to develop an intelligent, autonomous, and distributed manufacturing planning which can quickly and dynamically respond to the external and internal environment changes [8].

This paper investigated the literature for main gaps in relation to the production system first and the gaps in relation to the application of MAS models in the production field. Hence, considered as one of the contributions of this work, the main gaps were; production planning system is considered crucial for the success of the production, most of the current manufacturing planning systems, employed the hierarchical planning approach, which is characterized by structural rigidity, difficulty of designing a control system, and lack of flexibility. Moreover, most researches proposed software’s architectures, which allows for a consistent interaction of the heterogeneous planning and control systems, yet they don’t describe the system implementation process and the planning and control mechanism. In addition, even if many companies have implemented Manufacturing Resource Planning (MRPII) or ERP, these system cannot support the distributed manufacturing planning and control activities, because they lack enough communication capability to make real-time information flow available for partners, thus, they can’t timely solve problems. Furthermore, the literature mentioned the issue of the lack of appropriate software tools to support necessary tasks like distributed process planning and production control.

This study has proposed an integrated DPP approach for Moroccan Marble Manufacturing company for production planning appropriate to its production system. The main focus of this study was not the technical part but the conceptualisation of the model. The production planning requirements and parameters were investigated and aligned with MAS supported by SCADA mechanisms in the context of overcoming the issue of appropriately plan the production in terms of taking under consideration multiple parameters and reduce uncertainties and ambiguities in the Marble manufacturing company. Moreover, this paper reveals that very few papers tackled the integration of both models to solve the problem of production planning ambiguities and multi-parameters and overcome the complexity of the procedure. In this sense, this paper has developed an integrated DPP approach including both models based on MAS that could be regarded as a convenient framework for mathematical study and later on any other future research to develop an applicable system to support the production plan decision-making in distributed manufacturing.

References


